Teaching Accessible Design: Integrating Accessibility Principles and Practices into an Introductory Web Design Course

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Abstract

Curb cuts and automatic doors are a commonplace in the physical world as they provide access to our buildings for persons with disabilities. In the world of the web, millions of individuals have the legal right to rely on electronic curb cuts so they too can access the web. To this end, a new generation of information systems graduates must understand the dynamics of accessible web design. However, this subject is commonly taught as an add on topic with minimal impact on student knowledge and practice. Thus, the purpose of this article is to present an integrated approach to teaching accessible web design in an introductory web design course. The main contributions of this paper include (1) a background on web accessibility, (2) a review of pertinent assessment tools and legislation, and (3) a model for integrating web accessibility into an introductory web design course.

Keywords: Computing education, accessible design, web accessibility, integrative learning.

1. INTRODUCTION

As the world of the web continues to grow, its architects and caretakers serve an important role in the development and maintenance of an accessible digital world. In principle, the world of the web should be accessible to all regardless of their physical, sensory, or mental ability (W3c 2019b). However, in practice, this is not always the case because most sites found on the web contain some form of inaccessible elements that could have easily been remediated had the developer implemented some fundamental accessible design practices (Wettemann & White, 2019). Such inaccessibility can have a huge impact on businesses and institutions considering that nine in ten American adults use the internet and one in five has a disability that may affect their ability to use the internet (Teach Access, 2019b). In addition to the business perspective, many countries have legal requirements related to website accessibility (W3C WAI, 2019a).

Web developers who incorporate accessible design practices into their development process are in demand. In response, organizations and consortia such as AccessComputing, TeachAccess, W3C, and WebAim (AccessComputing, 2019; Teach Access, 2019a; W3C WAI, 2019c; WebAIM, 2019a) have worked to support and increase the numbers of faculty teaching and professionals practicing accessible design. While these resources are increasingly becoming more available, many information systems, computer science, and other interdisciplinary computing faculty feel they do not know enough about accessibility to teach the subject. Unfortunately, there is a lack of resources to help inexperienced faculty to incorporate accessibility topics into their curricula (Putnam, Dahman, Rose, Cheng, & Bradford 2016). When 1,857 computing and information science faculty members were surveyed, only 20% indicated that they incorporate topics about accessibility into their courses (Shinohara, Kawas, Ko, & Ladner, 2018). This is evident considering accessible design is typically not a fundamental component

to classroom instruction or textbook topics (Rosmaita, 2006).
In 2016, Putnam et al. examined how schools incorporate accessibility topics into their curriculum. They found a wide range of approaches which included standalone programs, standalone courses, integration throughout the entire program, integration throughout a single course, and as a module. When the researchers interviewed faculty, they found the most common prevalent practices were to either create a single course or provide a module in another course.

The aforementioned approaches have their benefits and disadvantages (e.g., deep dive in a single course vs. topic related exposure with a module). One approach that is particularly advantageous to the learning process, as supported by the Integrative Learning theory (Leonard & Jean, 2007; Leonard 2012), is the integration of accessible design principles and practices into the normal progression of a given course. Doing so allows students to make connections between accessible design and web development while they are "in the moment" of learning.

By teaching accessibility throughout the semester, students become more robust developers who view accessibility as part of the process rather than an afterthought. While multiple arguments can be made as to why information systems graduates must understand and implement accessible design practices (e.g., business, social responsibility, technological advancements, etc.), the bottom line is that accessible design practices should be as fundamental to our graduates as digital literacy. As more and more information systems and computing programs integrate web development courses into their curriculum, it is imperative that students understand the importance of integrating accessible design practices into the development process.

As previously indicated, researchers have identified a lack of instructional resources that are available to assist faculty with the incorporation of accessibility into their courses (Putnam, Dahman, Rose, Cheng, & Bradford 2016). Therefore, the overall purpose of this work is to assist faculty by contributing to the limited accessible instruction resources.

2. ALTERNATIVE METHODS FOR ACCESSING THE WEB

Before discussing accessible web design, it is important to discuss the interplay between adaptive technologies and web access/interaction. Adaptive technologies enable individuals with disabilities to access and interact with a web page by modifying a web page's content and interaction into a usable format. To this end, adaptive technologies are reliant on a web page's level of accessibility. If accessibility elements are lacking, then the adaptive technology's ability to convert page content into a usable format is hindered.

For example, a person who is blind could have a refreshable Braille device convert a web page into Braille. However, the Braille device is reliant on the electronic curb cuts built into the page (as are other adaptive technologies). To expand, consider a web page that describes how a computer works. Found on the page is a picture of the inside of a computer with all the parts labeled. If the image is not described with the alt text or the long description attribute, then the Braille device can only inform the user that an image exists. Nothing more. Any meaning found within the image (e.g., the different parts of a computer) is lost.

There exist a wide range of adaptive technologies to help individuals interact with the digital media found on the web. Some are hardware, some are software, and some are both. Table 1 (see Appendix) provides a general overview of how some individuals with various conditions use technologies to access web-based materials.

3. ACCESSIBLE WEB DESIGN: TECHNOLOGICAL, LEGAL, AND BUSINESS PERSPECTIVES

Integrating accessible design principles and practices into the progression of a web design course prepares graduates to handle future workforce responsibilities. From a technological perspective, graduates need to understand that accessible design enables a wide range of use by persons with disabilities and current technologies utilized by the general population. An example of this multi-use scenario is a voice-activated navigation program. Such a program can serve individuals who are blind (e.g., "fastest walking route to library") as well as drivers (e.g., "nearest gas station").

In terms of a legal perspective, many countries have instituted web accessibility regulations that require adherence. For example, the U.S. Congress enacted legislation to require public institutions to develop websites that are accessible to persons with disabilities. As part of that legislation, the U.S. Access Board created Section 508 Standards for Electronic and Information Technology (1998) and in 2017, the standards were revised to require 38 of the 61 new guidelines (Section 508, 2017) be met rather than the original 16 (Section 508, 2000). Further discussion on the guidelines is found in a later section.

By not complying with legislation, businesses run the risk of ending up in court. Companies such as Wells Fargo, H&R Block, and Target have had accessibility lawsuits brought against them. The result of which was substantial amounts of money being paid to the plaintiffs and civil penalties (Court Listener, 2009; LEAGLE, 2007; United States Department of Justice Civil Rights Division, 2011; United States Department of Justice, 2013). In addition, companies with inaccessible websites have had to pay millions to charitable organizations (United States Department of Justice Civil Rights Division, 2011).

Students should also understand the importance of accessible web design from a business perspective. More so, millions of people with and without disabilities around the world rely on well-designed web media. If this media is not accessible, a business could lose customers, inadvertently discriminate against employees with disabilities, experience lower rankings with search engines and reduced site traffic, and ultimately lose money. Concerning money loss due to low internet search rankings, Moreno & Martinez (2013) found that search engines interpret an accessible website as an indicator of quality and that the accessibility features allow for the search engine to better access and index a web page's content. To this end, search engine optimization (SEO) is tied with website accessibility.

Given the importance of web accessibility, faculty should be graduating information systems and computing students who incorporate accessible design practices into their development process. While faculty support the idea of teaching accessibility, barriers to doing so include their lack of expertise and sub-area materials (Shinohara et al. 2018). The following aims to help faculty overcome these barriers.

4. ACCESSIBLE WEB DESIGN INSTRUCTION

When instructing on accessible web design principles and practices it is important to incorporate the most recent assessment tools, accessibility standards and practices. As of January 2019, the current U.S. and international standards for web accessibility can be found in the Web Content Accessibility Guidelines 2.0 (2019c). The following includes a review of WCAG 2.0, assessment tools, followed by an alignment of WCAG guidelines to a typical intro to web development course.

WCAG 2.0 Explained

In the simplest terms, accessible web design can be defined as the creation of web resources in a manner that is usable by all. W3C has sought to maximize the usability of web resources through the creation of WCAG 2.0 which consists of four principles that branch into 12 guideline categories which further branch into 61 specific guidelines. Success criteria for these guidelines are based on three levels of conformance - A, AA, and AAA. Each level requires conformance to the previous level. A page that conforms to level AA is considered to be reasonably accessible and conforms to U.S. legislative requirements. A page that also includes level AAA requirements can be considered highly accessible. For example, providing captions would meet level A and providing captions and a sign language interpretation would meet level AAA. Captions alone in this situation would be considered reasonable.

It should be noted that WCAG 2.0 (2019c) was updated to WCAG 2.1 in June 2018 (2019d). For the most part, the update expands upon 2.0 to improve accessibility for users of mobile devices, users with low vision (a.k.a., "partial sight"), and users with cognitive or learning disabilities. To date, resources have not been developed to fully implement the updates. However, updates that relate to an introductory web design course will be discussed.

Accessibility Assessment Tools

The accessibility assessment of a web page is typically accomplished in two stages. First and foremost is to check if the page is technically correct (e.g., proper use of structure and markup). W3C's Markup Validation Service (2019a) is a free resource that should be in every student's (and professional's) toolbox (Figure 1). This service provides a detailed report on technical issues found in a web page. If these technical issues are not addressed, the functionality of adaptive technologies used to

access web pages can be hindered. For example, if an <h1> is not closed then a screen reader might treat all content on a page as an <h1>.

Once a page is to be determined to contain valid HTML, the second stage is to assess for accessibility. W3C provides a list of 92 web accessibility evaluation tools that can help students determine if their web content meets accessibility guidelines (W3C 2019b). While there

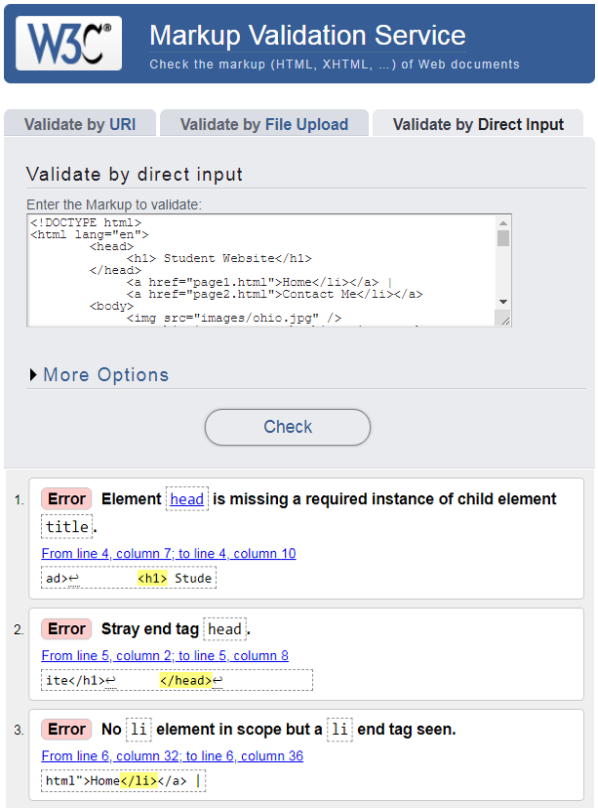

Figure 1: W3C's markup validation assessment results

are many tools available, students tend to appreciate AChecker (2019) as it is free, and reports are easy to understand (Figure 2). In addition, AChecker allows the user to choose which set of guidelines they would like to assess against. Its default is the U.S. standard of WCAG 2.0 set to level AA. While the accessibility evaluation tools help to automate the process, human input is needed for multiple guidelines (W3C WAI, 2019d). For example, the automated process cannot check for captions or if the captions are correct.

W3C's Markup Validation Service and AChecker are invaluable instructional resources as they enable students to independently understand and improve their web development practices. Additionally, both tools facilitate the grading process as they automate the error finding process. Over time, the use of these tools should become part of a student's development process - especially when attempting to identify why their page is acting inappropriately. The timing of introducing these tools will be discussed below.

Once students are exposed to the assessment tools and guidelines, instruction on the guidelines can be done in a manner that complements course content as the semester progresses. An appropriate application of this approach is to include accessibility guidelines during lectures and assignments for any given topic that directly relates to accessible design. By doing so, the connection between classroom concepts and accessibility practices can be strengthened.

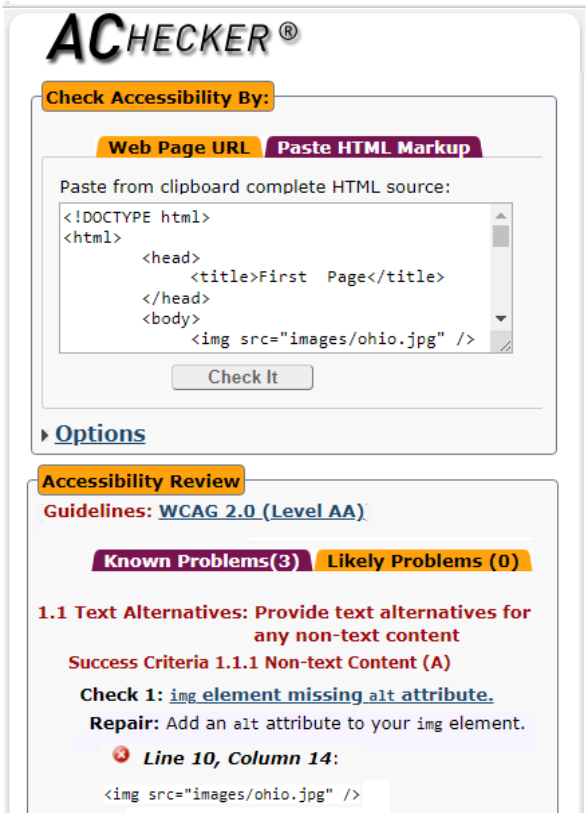

Figure 2: AChecker accessibility evaluation results

5. INTRO WEB DESIGN COURSE PROGRESSION

A fundamental concept of this work is the promotion of an integrated instructional approach where accessible design principles and practices are part and parcel to the progression of course content. Whenever course lessons have a corresponding accessible design approach, the approach is also integrated into the lesson.

The following is a step-by-step representation of course topics as they would commonly appear in a typical intro to web design course progression, their corresponding accessible guideline and importance, and a teaching tip discussion. While the following includes Hypertext Markup Language (HTML) and Cascading Style Sheets (CSS), it is understandable that not all intro courses will include the same content. To this end, readers can pick and choose which sections apply to their course. The reader will also note that some of the accessible practices might already be covered in an introductory course (e.g., valid HTML). However, the takeaway point is the relationship and importance that practice has to accessibility. Lastly, not all guidelines are present in the following material. This is purposeful as the focus of this work is to complement the introductory course and start the development of an accessible design mindset among students.

It should be noted that this work has been developed over multiple semesters by the same instructor who incorporates active learning in a flipped classroom environment. The delivery of the course is as follows. Readings are assigned and completed before class. The readings are made up of material from the textbook and external accessibility materials (when appropriate). Classes start with a short lecture and discussion where topics are reviewed in preparation for the upcoming activities. If there was an accessibility component in the readings, then students can expect to integrate said component into their upcoming activities and coursework. Activities and coursework include small labs, larger projects, quizzes, and exams.

Hypertext Markup Language

The difference between accessible HTML and non-accessible HTML is a slight one. With a few additions and modified implementations, non-accessible markup practices can easily be remediated. As previously indicated, adaptive technologies (and others) rely on the correct implementation of the semantic and syntactic markup found on a page. For the most part, an accessible designer needs to be conscious of the small tweaks to make a page accessible.

To this end, complementing HTML instruction with accessibility features is a straightforward process that takes a minimal amount of time. For example, when presenting on images it would take less than two minutes to discuss why one would need to include an alternative description for people who cannot see the image. Requiring alternative descriptions on assignments and testing on their importance/implementation reinforces good practice.

Valid HTML

Structure and markup are some of the first things a student learns in an introductory course. As modern devices and accessible technologies rely on valid HTML, students should develop valid code from the beginning. At this point in the progression of the course, the student should be introduced to W3C's validator (2019a) and begin learning how to check their work. By validating their work, they are complying with WCAG Success Criterion "4.1.1 Parsing: In content implemented using markup languages, elements have complete start and end tags, elements are nested according to their specifications, elements do not contain duplicate attributes, and any IDs are unique, except where the specifications allow these features" (W3C, 2019c).

At times, textbooks introduce the DOCTYPE declaration discussion (i.e., <!DOCTYPE html>) later in the chapters. This topic should be moved up before the use of W3C's validator as its presence is required by the validator.

<title> & <html lang="en">

The title element serves to orient the user to the content without having to process the content (WCAG Success Criterion 2.4.2) and the lang attribute serves to identify the language used throughout the document (WCAG Success Criterion 3.1.1). An example of the importance of the <title> tag is a page that contains a large amount of top matter (e.g., navigation, advertisements, etc.). A sighted user could scan past these elements and understand what the focus of the page is but a person who is blind would need to have their screen reader process all the top matter before discovering the focus of the page. A quick check with W3C validator or AChecker will reveal to the student whether or not they have included title tag and lang attribute.

Headings <h1>, <h2>, <h3>, <h4>, <h5>
Headings are utilized by adaptive technologies to quickly navigate a web page. It is important that they be used to describe a topic or purpose (WCAG Success Criterion 2.4.6) rather than for visual effect. In addition, headers should be used with an appropriate hierarchy structure. Manual checks are needed as automated checkers will not pick up on contextual use.

<a href....>
Link names need to be purposeful / in context (WCAG Success Criterion 2.4.4). Adaptive technologies can list all the links on a page so a user of adaptive technologies might scan them as quickly as a visual user might scan a page. If the links are not meaningful such as "click me" or "click here" then they become useless to the user of adaptive technologies. Validation tools will not be able to identify if a link is purposeful.
<nav>
Users of screen magnification are reliant on their spatial memory for items on a page. To this end, consistent navigation across multiple web pages (WCAG Success Criterion 3.2.3) eases the burden of memorizing a different layout for each page. Human input is required to assess consistent navigation.

<img>
Images (non-text content) visually convey information and are inaccessible to those who cannot see them. Consequently, a text alternative is required (WCAG Success Criterion 1.1.1). This is typically accomplished with an alt attribute which provides a concise description of the image. If a short description is not enough for a complex image then the use of the longdesc attribute is necessary (e.g., link to a detailed description). Examples would include an alt= "two baby ducks on the water" for a short description of two ducks or longdesc= "http://www.doublehelix.com" for a long description of a double helix. Both W3C validator and AChecker will identify images with no alt attributes but human input is required to determine the need for a longdesc attribute.

As students explore images (e.g., JPEG, PNG, GIF), it is important to address GIF images that flash more than three times per second. According to WCAG Success Criterion 2.3.1, anything that flashes more than three times per second can cause an individual with a seizure disorder to have a seizure. While other accessible design practices address the removal of access barriers, WCAG Success Criterion 2.3.1 directly addresses a practice that can cause a medical issue (i.e., seizure). To this end, students must learn early on to never include anything that flashes more than three times a second. This Success Criterion should be taken into consideration with CSS techniques discovered later in the semester. Human input is required to assess flashing content.

<table>
Tables can range from simple to complex. For those that cannot see a table, it becomes more and more difficult to relate individual cell data to a specific row and column the more complex a table becomes. According to WCAG Success Criterion 1.3.1 Info and Relationships: Information, structure, and relationships conveyed through presentation can be programmatically determined or are available in text. Depending on the complexity of the table, this means the inclusion of caption, summary, headers, and scope. For simple tables, caption and headers are sufficient. More complex tables require all four. Human input is required to determine the complexity of a table.

<form>
Forms provide the user with a means to interact with a website. For a form to be usable, it must be navigable (WCAG Success Criterion 2.4.6) and provide input assistance (WCAG Success Criterion 3.3.2) as accomplished with the <label> element and the <fieldset> and <legend> grouping controls. A <label> element is required on all form controls, but the implementation of grouping controls is reliant on the complexity of the form. An example of the importance of the <label> tag can be explained with a simple form that has a handful of inputs (e.g., name, age, date of birth, etc.). If the form does not have labels, a screen reader will not be able to inform a blind user which input field their cursor is currently located. When the label is used, the screen reader can inform the user what input data is expected. AChecker automatically identifies missing labels.

WCAG 2.1 added WCAG Success Criterion 1.3.5: Identify Input Purpose to help individuals identify and understand the purpose of form inputs. The best recommendation for doing so is by using the autocomplete attribute which describes the meaning of a given value. As of writing, AChecker does not assess for 1.3.5.

<audio><video>
Individuals who are deaf or hard of hearing are not able to process audio content found in audio and video and individuals who are blind are not able to process visual information presented in videos. To this end, the audio needs to be

captioned and video needs an audio description (WCAG Success Criterion 1.2). As the creation and manipulation of audio and video are out of the scope of an intro class, it is best to discuss the implications and responsibilities of including audio and video on a web page.

Audio that automatically plays can make it difficult for those who use screen reading software to process the automatic audio and the screen reader audio at the same time. This condition makes it important for the individual to be able to control the audio by either stopping it or controlling the volume independently from the system volume level (WCAG Success Criterion 1.4.2 Audio Control). To this end, students should learn to include controls with their audio or video (e.g., <audio controls>).

Cascading Style Sheets
At this point in the course, students have learned how to create accessible content with properly structured HTML. With CSS, students will need to become more reliant on their ability to identify and incorporate accessible design principles and practices into their development process. The need for this change is because most automated accessibility checkers are unable to identify CSS based accessibility issues. However, at this point in the semester, accessible design is nothing new and the following accessibility recommendations are within a student's ability to incorporate into their design process.

Color
One of the early stages of CSS instruction is the manipulation of color on HTML elements to enhance aesthetic appeal. While fun, students should understand that many individuals experience limited color vision (e.g., color blind, partial sight, blind, etc.) and therefore have difficulty perceiving color. To this end, color should not be used as the only visual means to convey information, indicating an action, prompting a response, or distinguishing a visual element (WCAG Success Criterion 1.4.1). Examples include "click the red…" or "yellow indicates required". For the most part, students should learn not to use color in such cases. Although, if it is required, an alternative means such as alternative text for an icon should be used. Human input (e.g., the developer) is required to determine if color is being used appropriately.

Contrast
Individuals with moderately low vision rely on the contrast between text and its background so they can read the text. WCAG Success Criterion 1.4.3 requires at least 4.5:1 for normal text and 3:1 for large text. WebAIM (2019b) provides a free online color contrast checker which is simple for students to use.

Layout
HTML is processed top to bottom by the browser and various adaptive technologies. With CSS, it is possible to change this sequence and locate content anywhere on the page (e.g., static positioning, float). Doing so can create a new content representation sequence that takes on a different meaning than the sequence found in the HTML. WCAG Success Criterion 1.3.2 puts forth that it is acceptable to position content throughout the page for visual effect, but the sequence found in the HTML must be maintained.

Flashing with Animation
As stated previously, anything that flashes more than three times per second can cause an individual with a seizure disorder to have a seizure (WCAG Success Criterion 2.3.1). With CSS it is possible for students to use the animation property to create an effect that can cause a seizure (i.e., animation-duration: .25s; animation-iteration-count: 10;). Students must learn to never implement anything that flashes more than three times per second. To this end, if the animation property is part of the course progression then it should be used with caution by both the faculty and students.

Responsive Design
According to WCAG 2.1 WCAG Success Criterion 1.4.10: Reflow, content should be presented without the need to scroll in two dimensions. To expand, people with low vision magnify a page and upon magnification, this page should flow into one column so scrolling is only necessary for one direction (typically vertical). To this end, students should learn about the use of static dimensions as a practice that should only be used if necessary (e.g., the two-dimensional layout is needed for meaning) as a fluid design is more appropriate.

6. TEACHING EXPERIENCE

This approach to infusing accessible design principles and practices throughout the semester stemmed from the need to improve upon the single accessibility lecture approach. To expand, the course was taught with a single accessibility lecture over a period of 1.5 years. This practice created a trend where many students would only design accessibly if there was an explicit

requirement to do so. Rather than updating assignment requirements and furthering the perception that accessibility is only needed when required, the instructional approach for the course was updated to instill upon students that accessibility is a fundamental component of the web design process. Overlooking its inclusion constituted sub-standard work.

Over the past two years in the introductory web design course, the integrated approach positively influenced how the students perceived and practiced accessible design. More so, once an accessibility principle or practice is covered, there is an implicit expectation that it will be included in future work. Failure to include accessibility practices results in a point deduction which was rarely needed to enforce as the semester progressed. By integrating accessible design early and often, a solid foundation is created on which students can build upon and, ultimately, become professionals capable of understanding, creating, and maintaining an accessible digital world.

7. CONCLUSION

As previously indicated, many faculty have reported a lack of accessibility expertise and sub-area materials. Furthermore, only 20% of faculty teach courses that incorporate accessibility topics (Shinohara et al. 2018). The result of this is a generation of graduates who do not know about accessibility. This is problematic as 63% of companies reported that their staff does not have enough accessible technology skills (Teach Access, 2019b). If this is to change, faculty will need to incorporate accessibility into their teaching practices and, on a larger scale, departments will need to examine how accessibility can be integrated into the core curriculum. To this end, the following are recommendations on how to improve, through research and practice, the current status of accessibility instruction.

- Investigate where accessibility instruction fits into specific courses/topics (e.g., software engineering, mobile application development, etc.).
- Investigate what motivators lead to the adoption of accessibility instruction.
- Create and disseminate materials/modules that can be directly integrated into specific courses and topics.
- Develop instructional opportunities for faculty to learn the importance of accessibility and how to integrate accessibility into their course.

As our digital world continues to grow, it is important that a new generation of information systems and computing graduates are prepared to maintain/create new spaces and interactions that are accessible to all. With a collective effort, academia can help make this happen.

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Appendix

Condition	Accessibility Barrier	Technologies used to Overcome Barrier
Blind	Visual materials	Screen Reader
Color Blind	Use of color	Custom Cascading Style Sheets
Low Vision	Content size	Screen magnification program
Mobility Impairments	Hardware requirements such as mouse use (e.g., click here)	Keyboard entry, voice activated control, switches, eye gaze technology, etc.
Deaf / Hard of Hearing	Audio cues, audio tracks	Sound notification, amplification

Table 1. Web Access Barriers and Practices